TITLE (ELIMINATION OF LIFTED BALL BOND ABNROMALITY ON SQFP PACKAGE)

Gerald V. Pascua

Assembly FOL Process Engineering
Onsemi Tarlac, LIP SEPZ San Miguel, Tarlac City
Gerald.Pascua@onsemi.com

ABSTRACT

This project aims to address the persistent issue of lifted ball bond defects encountered in the wire bond process of SQFP (Small Quad Flat Package) components at OSPI Tarlac LSI department. The occurrence of lifted ball bonds has been identified as the top abnormality leading to quality feedback from January 2022 to December 2022, posing significant risks to product quality, productivity, and customer satisfaction.

The problem statement highlights an average of 4 RBFA (Reportable Abnormality Failure Analysis) GMRB (Global Manufacturing Review Board) feedback cases per month, underscoring the critical nature of the defect, as it remains undetected by existing wire bond machines. Lifted ball bonds result in compromised device reliability and functionality, necessitating urgent remediation.

The goal of this project is to eliminate Lifted Ball GMRB feedback for SQFP package models, reducing the occurrence from 4 cases per month to zero by November 2023. To achieve this, the project scope encompasses activities from the wire bond process to pre-seal inspection, specifically targeting the SQFP package. Other packages are explicitly excluded from the scope.

Upon successful completion, the project is anticipated to yield significant benefits, including an estimated annual cost saving of $3,098.00. By addressing the root cause of lifted ball bond defects, the project aligns with the corporate strategy towards achieving zero defects, thereby enhancing product quality, productivity, and overall customer satisfaction.

1. 0 INTRODUCTION

In the dynamic landscape of semiconductor manufacturing, ensuring product quality is paramount to sustaining competitive advantage and meeting customer expectations. Within the OSPI Tarlac LSI department, the persistent occurrence of lifted ball bond defects on SQFP (Small Quad Flat Package) components has emerged as a pressing concern. From January 2022 to December 2022, this issue has consistently ranked as the highest abnormality, precipitating quality feedback and posing substantial risks to operational efficiency and customer satisfaction.

Lifted ball bonds, characterized by their critical nature and undetectability by existing wire bond machines, present a significant challenge to product reliability and functionality. The detrimental impact of these defects underscores the urgent need for intervention to safeguard the integrity of our manufacturing processes and uphold our commitment to delivering high-quality products.

In response to this imperative, the proposed project seeks to eliminate lifted ball bond defects on SQFP packages, thereby enhancing product quality, productivity, and cost-effectiveness. By addressing the root cause of this anomaly and implementing targeted corrective measures, we aim to not only mitigate immediate risks but also align with our overarching corporate strategy of achieving zero defects.

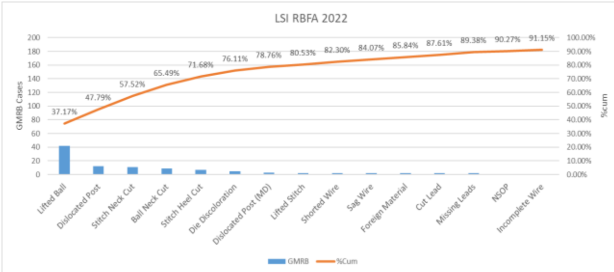
This introduction sets the stage for a comprehensive exploration of the project's objectives, scope, methodology, and anticipated outcomes, underscoring its significance in driving continuous improvement and ensuring the long-term success of our operations.

1.1 The Sub-major Heading

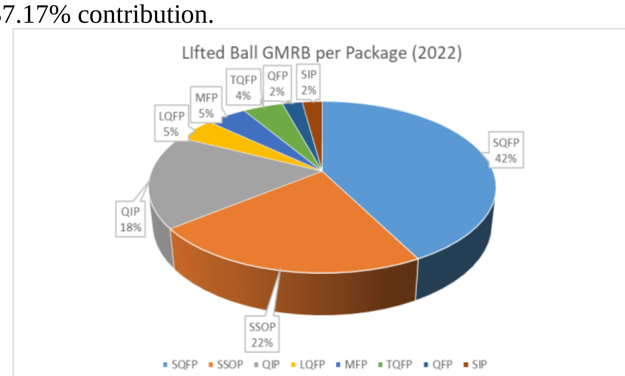
Project Overview and Strategy

1.1.1 Second Level Subheading

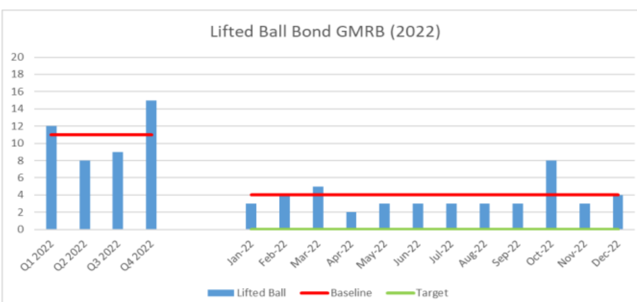
"Understanding the Problem: Lifted Ball Bond Defects"



For 2022, the top GMRB occurrence at LSI RBFA is Lifted Ball bond with a total of 42 cases which is equivalent to 37.17% contribution.



42% of the Lifted ball bond GMRBs are from SQFP package.



Lifted Ball Bond GMRB occurrence is averaging 4 case per month and 11 cases per quarter. The project target is to eliminate the lifted ball bond GMRB.

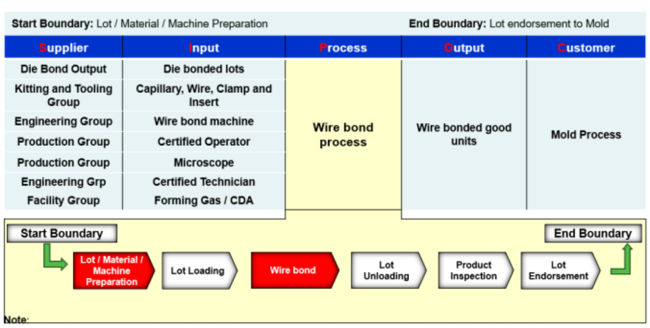


Figure 1: SIPOC

Lifted Ball is detached from bond pad, thus having little or no connection between the wire and the die pad.

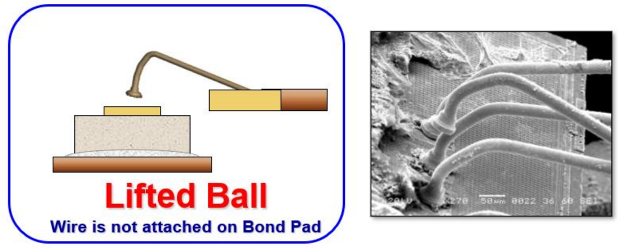


Figure 2: Definition of lifted ball bond

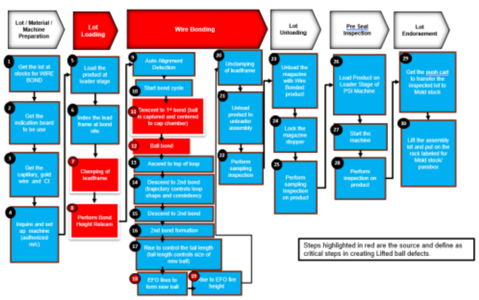
2. 0 REVIEW OF RELATED WORK

In reviewing related data for this project, the author extensively examined information on wire bonding processes and defect mitigation strategies. This involved analyzing internal data on lifted ball bond defects, process inefficiencies, and quality improvement initiatives. Additionally, external sources such as industry reports and case studies were reviewed to gain insights into best practices and emerging trends. By synthesizing data from various sources, the author developed a comprehensive understanding of the challenges and opportunities in wire bonding processes, which informed the project's methodology and decision-making process. This data-driven approach aims to drive continuous improvement and innovation while aligning with industry standards.

3.0 METHODOLOGY

The methodology begins with a thorough analysis of the wire bond process, employing process mapping and Fishbone diagram techniques to identify potential causes of lifted ball bond defects. Next, a comprehensive list of Key Process Input Variables (KPIVs) is compiled and refined through grouping and prioritization based on their impact and feasibility. Validation plans are then formulated for the prioritized KPIVs, delineating objectives, methodologies, and responsibilities. These plans guide the execution of validation activities, including data collection and assessment against predefined criteria to determine the validity of each KPIV. Following validation, the KPIVs found to have a significant impact on lifted ball bond defects are identified for further improvement efforts in the subsequent phase. Key validated KPIVs include inconsistent tail formation after error reset, dirty wire clamper, low vacuum, and inconsistent vacuum supply, and over stagging of leadframe in heated feeder. This structured approach ensures a systematic and targeted approach to addressing the root causes of lifted ball bond defects, ultimately enhancing the quality and reliability of the wire bond process.

Cause-Effect Analysis: Detailed Process Map / SIPOC



Steps highlighted in red are the source and define as critical steps in creating Lifted ball defects.

Analysis Summary:

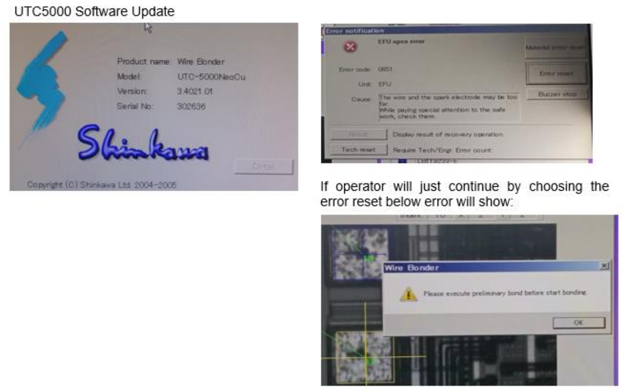
- ❑ Identification of KPIVs: Detailed process analysis was done using process mapping and Fishbone diagram. Initially, 90 KPIVs were identified and shortlisted after grouping of similar KPIVs. The team prioritized 24 KPIVs for validation after ranking of identified KPIVs. 7 validation plan was formulated by the team.
- ❑ After validation of a prioritized KPIVs, 4 are found valid and now to be addressed in Improve Phase.

1. Inconsistent Tail formation after error reset
2. Dirty wire clamper
3. Low vacuum and inconsistent vacuum supply
4. Overstagging of leadframe in heated feeder

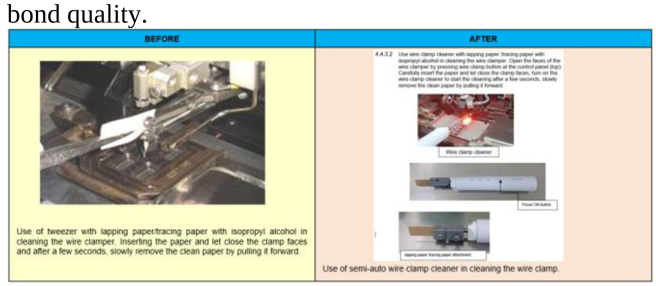
4.0 RESULTS AND DISCUSSION

The solution development and selection phase of the project involved the implementation of corrective and preventive actions (CAPAs) targeting the four validated Key Process Input Variables (KPIVs) identified earlier. These CAPAs focused on both system/process improvements and part redesign to effectively address the root causes of lifted ball bond defects.

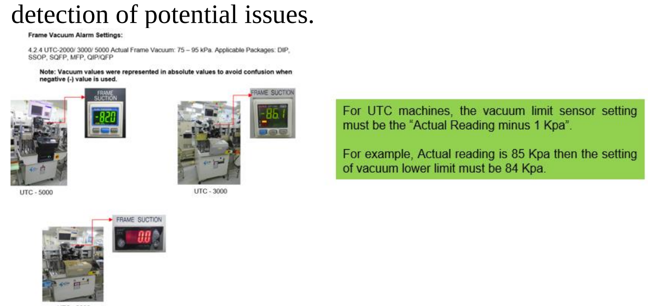
Firstly, force wire threading was implemented on high-end wire bond machines to ensure the availability of a new/fresh wire tail after machine error occurrences, thereby enhancing the reliability of wire bonding processes.



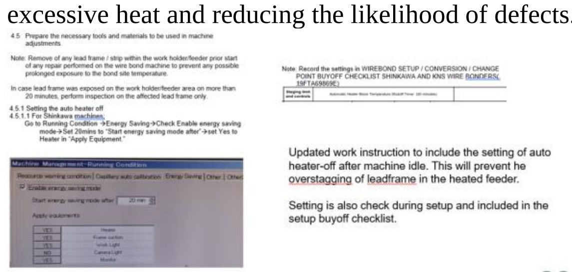
Additionally, a semi-automatic wire clamper cleaner was introduced to mitigate the impact of dirty wire clampers on bond quality.



Furthermore, adjustments were made to tighten the vacuum lower limit setting to facilitate early detection of foreign material (FM) presence under the device island, minimizing the risk of lifted ball bond defects. Specifically, for machines, the vacuum limit sensor setting was calibrated to be "Actual Reading minus 2 Kpa" to ensure proactive detection of potential issues.

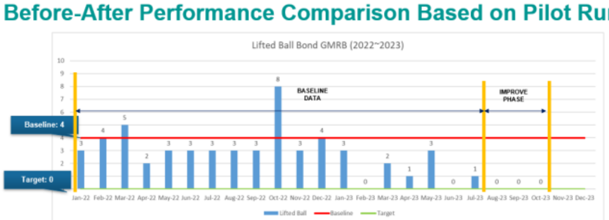


Lastly, an auto shut-off mechanism for heater block temperature was implemented after 20 minutes of idle time following machine errors, preventing prolonged exposure to excessive heat and reducing the likelihood of defects.



The before-after performance comparison demonstrated significant improvements in lifted ball bond defects for SQFP packages following the implementation of the identified CAPAs. RBFA feedback for lifted ball bond defects was consistently eliminated from August 2023 onwards, indicating the effectiveness of the implemented solutions in mitigating the root causes of defects and enhancing overall product quality.

Before-After Performance Comparison Based on Pilot Run



CAPA	Description	Implemented
1	Implementation of force wire threading on high end wirebond machines (UTC5000) to have new/fresh wire tail after occurrence machine error.	WW34'23
2	Implementation of semi-auto wire clamper cleaner .	WW35'23
3	Tightening of Vacuum lower limit setting for early detection of FM presence under the device island. For UTC machines, the vacuum limit sensor setting must be the "Actual Reading minus 1 Kpa". For example, Actual reading is 85 Kpa then the setting of vacuum lower limit must be 83 Kpa.	WW32'23
4	Implementation of auto shut-off of heater block temperature after machine error after 20 minutes idle time.	WW31'23

✓ Achieves the target of Zero lifted ball RBFA feedback for SQFP package after completion of CAPA.

In conclusion, the successful implementation of targeted CAPAs has led to a substantial reduction in lifted ball bond defects, thereby improving product quality, productivity, and customer satisfaction. These results underscore the importance of systematic problem-solving methodologies and proactive interventions in addressing complex manufacturing challenges and achieving operational excellence. Moving forward, continued monitoring and optimization efforts will be essential to sustain these improvements and drive continuous advancement in manufacturing processes..

5.0 CONCLUSION

The project effectively addressed lifted ball bond defects at onsemi Tarlac through rigorous analysis and targeted actions, leading to significant improvements in product quality. The author's (Gerald V. Pascua) leadership was pivotal in guiding the team. The outcomes emphasize the importance of systematic problem-solving and collaboration in semiconductor manufacturing, with lessons learned informing future initiatives for quality enhancement.

6.0 RECOMMENDATIONS

Recommended to fan-out improvement actions to other packages and other machine model to magnify result.

7.0 ACKNOWLEDGMENT

We extend our heartfelt gratitude to all who contributed to the success of this project. Thanks to the management team for their guidance, the project team for their dedication, and colleagues across departments for their collaboration. Special appreciation to external partners and vendors for their support. We also acknowledge the valuable input from our customers. Together, your efforts have been instrumental in driving positive change and advancing our commitment to quality excellence.

8.0 REFERENCES

N/A

9.0 ABOUT THE AUTHORS

Since joining onsemi Tarlac in 2012, the project author Gerald V. Pascua, an Electronics Communication Engineer, has been instrumental in enhancing manufacturing standards and achieving company objectives. With over a decade of experience in semiconductor manufacturing, particularly in wire bonding processes, they bring a wealth of knowledge and expertise to their role.

As Section Head of Wire Bonding Process Engineering, the author has led wire bonding operations with a focus on efficiency, quality, and continuous improvement. Their leadership has been crucial in shaping the strategic direction and operational excellence of the wire bonding department.

Additionally, serving as the Wire Bonding Process Subject Matter Expert for Ball and Wedge bonding, they have guided and mentored team members, fostering a culture of excellence and innovation. Throughout their tenure, the author has demonstrated unwavering dedication to enhancing processes, addressing defects, and elevating product quality.

Their role as a thought leader and problem solver has been evident in their ability to analyze complex issues, devise targeted solutions, and achieve successful project outcomes. Their ongoing commitment to excellence continues to drive success and innovation within the wire bonding process engineering department at onsemi Tarlac.

10.0 APPENDIX

N/A